

What is claimed is:

- 1 1. A program debugger, for use in a programming environment, comprising:
2 means for extracting, from an initial conditional breakpoint within a program
3 loop, a first Boolean expression that is at least partially invariant within the loop;
4 means for removing said initial conditional breakpoint;
5 means for setting, at a pre-ICB program position, a special conditional
6 breakpoint that includes said first Boolean expression; and
7 means for reestablishing said initial conditional breakpoint if said special
8 conditional breakpoint is satisfied.

- 1 2. The program debugger of claim 1, wherein said first Boolean expression is
2 completely invariant within the loop.

- 1 3. The program debugger of claim 1, further comprising:
2 means for setting, at a first loop exit program position, a first reset breakpoint;
3 and
4 means for removing said initial conditional breakpoint if said first reset
5 breakpoint is satisfied.

- 1 4. The program debugger of claim 3, further comprising:
2 means for removing said first reset breakpoint if said first reset breakpoint is
3 satisfied.

1 5. The program debugger of claim 3, further comprising:
2 means for setting, at a second loop exit program position, a second reset
3 breakpoint; and
4 means for removing said initial conditional breakpoint if one of said first and
5 second reset breakpoints is satisfied.

1 6. The program debugger of claim 5, further comprising:
2 means for removing said first and second reset breakpoints if one of said first
3 and second reset breakpoints is satisfied.

1 7. The program debugger of claim 1, further comprising:
2 means for extracting, from program code within the loop, a second Boolean
3 expression that is invariant within the loop,
4 wherein said special conditional breakpoint disjunctively includes the
5 complement of said second Boolean expression, and said first Boolean expression is
6 invariant within the loop when said second Boolean expression is satisfied.

1 8. The program debugger of claim 7, further comprising:
2 means for setting, at a first loop exit program position, a first reset breakpoint;
3 and
4 means for removing said initial conditional breakpoint if said first reset
5 breakpoint is satisfied.

1 9. The program debugger of claim 8, further comprising:
2 means for removing said first reset breakpoint if said first reset breakpoint is
3 satisfied.

1 10. The program debugger of claim 8, further comprising:
2 means for setting, at a second loop exit program position, a second reset
3 breakpoint; and
4 means for removing said initial conditional breakpoint if one of said first and
5 second reset breakpoints is satisfied.

1 11. The program debugger of claim 10, further comprising:
2 means for removing said first and second reset breakpoints if one of said first
3 and second reset breakpoints is satisfied.

1 12. A method of reducing debugger impact through conditional breakpoint
2 motion, comprising:
3 extracting, from an initial conditional breakpoint within a program loop, a first
4 Boolean expression that is at least partially invariant within the loop;
5 removing said initial conditional breakpoint;
6 setting, at a pre-ICB program position, a special conditional breakpoint that
7 includes said first Boolean expression; and
8 if said special conditional breakpoint is satisfied, reestablishing said initial
9 conditional breakpoint.

1 13. The method of claim 12, wherein said first Boolean expression is
2 completely invariant within the loop.

1 14. The method of claim 12, further comprising:
2 setting, at a first loop exit program position, a first reset breakpoint; and
3 if said first reset breakpoint is satisfied, removing said initial conditional
4 breakpoint.

1 15. The method of claim 14, further comprising:
2 if said first reset breakpoint is satisfied, removing said first reset breakpoint.

1 16. The method of claim 14, further comprising:
2 setting, at a second loop exit program position, a second reset breakpoint; and
3 if one of said first and second reset breakpoints is satisfied, removing said
4 initial conditional breakpoint.

1 17. The method of claim 16, further comprising:
2 if one of said first and second reset breakpoints is satisfied, removing said first
3 and second reset breakpoints.

1 18. The method of claim 12, further comprising:
2 extracting, from program code within the loop, a second Boolean expression
3 that is invariant within the loop,
4 wherein said special conditional breakpoint disjunctively includes the
5 complement of said second Boolean expression, and said first Boolean expression is
6 invariant within the loop when said second Boolean expression is satisfied.

1 19. The method of claim 18, further comprising:
2 setting, at a first loop exit program position, a first reset breakpoint; and
3 if said first reset breakpoint is satisfied, removing said initial conditional
4 breakpoint.

1 20. The method of claim 19, further comprising:
2 if said first reset breakpoint is satisfied, removing said first reset breakpoint.

1 21. The method of claim 19, further comprising:
2 setting, at a second loop exit program position, a second reset breakpoint; and
3 if one of said first and second reset breakpoints is satisfied, removing said
4 initial conditional breakpoint.

1 22. The method of claim 21, further comprising:
2 if one of said first and second reset breakpoints is satisfied, removing said first
3 and second reset breakpoints.

1 23. An article of manufacture comprising a computer program medium
2 readable by a computer and embodying one or more instructions executable by the
3 computer to perform a method of reducing debugger impact through conditional
4 breakpoint motion, the method comprising:
5 extracting, from an initial conditional breakpoint within a program loop, a first
6 Boolean expression that is at least partially invariant within the loop;
7 removing said initial conditional breakpoint;
8 setting, at a pre-ICB program position, a special conditional breakpoint that
9 includes said first Boolean expression; and
10 if said special conditional breakpoint is satisfied, reestablishing said initial
11 conditional breakpoint.

1 24. The article of manufacture of claim 23, wherein the first Boolean
2 expression is completely invariant within the loop.

1 25. The article of manufacture of claim 23, wherein the method further
2 comprises:
3 setting, at a first loop exit program position, a first reset breakpoint; and
4 if said first reset breakpoint is satisfied, removing said initial conditional
5 breakpoint.

1 26. The article of manufacture of claim 25, wherein the method further
2 comprises:
3 if said first reset breakpoint is satisfied, removing said first reset breakpoint.

1 27. The article of manufacture of claim 25, wherein the method further
2 comprises:

3 setting, at a second loop exit program position, a second reset breakpoint; and
4 if one of said first and second reset breakpoints is satisfied, removing said
5 initial conditional breakpoint.

1 28. The article of manufacture of claim 27, wherein the method further
2 comprises:

3 if one of said first and second reset breakpoints is satisfied, removing said first
4 and second reset breakpoints.

1 29. The article of manufacture of claim 23, wherein said first Boolean
2 expression is partially invariant within the loop, and the method further
3 comprises:

4 extracting, from program code within the loop, a second Boolean expression
5 that is invariant within the loop,
6 wherein said special conditional breakpoint disjunctively includes the
7 complement of said second Boolean expression, and said first Boolean expression is
8 invariant within the loop when said second Boolean expression is satisfied.

1 30. The article of manufacture of claim 29, wherein the method further
2 comprises:

3 setting, at a first loop exit program position, a first reset breakpoint; and
4 if said first reset breakpoint is satisfied, removing said initial conditional
5 breakpoint.

1 31. The article of manufacture of claim 30, wherein the method further

2 comprises:

3 if said first reset breakpoint is satisfied, removing said first reset breakpoint.

1 32. The article of manufacture of claim 30, wherein the method further

2 comprises:

3 setting, at a second loop exit program position, a second reset breakpoint; and

4 if one of said first and second reset breakpoints is satisfied, removing said

5 initial conditional breakpoint.

1 33. The article of manufacture of claim 32, wherein the method further

2 comprises:

3 if one of said first and second reset breakpoints is satisfied, removing said first

4 and second reset breakpoints.

1 34. A program debugger, for use in a programming environment, comprising:

2 means for extracting, from an initial conditional breakpoint within a program

3 loop, a first Boolean expression that is at least partially invariant within the loop;

4 means for setting, at a pre-ICB program position, a special conditional

5 breakpoint that includes the complement of said first Boolean expression; and

6 means for removing said initial conditional breakpoint if said special

7 conditional breakpoint is satisfied.

1 35. The program debugger of claim 34, wherein said first Boolean expression

2 is completely invariant within the loop.

1 36. The program debugger of claim 34, further comprising:
2 means for setting, at a first loop exit program position, a first reset breakpoint;
3 and
4 means for reestablishing said initial conditional breakpoint if said first reset
5 breakpoint is satisfied.

1 37. The program debugger of claim 36, further comprising:
2 means for removing said first reset breakpoint if said first reset breakpoint is
3 satisfied.

1 38. The program debugger of claim 36, further comprising:
2 means for setting, at a second loop exit program position, a second reset
3 breakpoint; and
4 means for reestablishing said initial conditional breakpoint if one of said first
5 and second reset breakpoints is satisfied.

1 39. The program debugger of claim 38, further comprising:
2 means for removing said first and second reset breakpoints if one of said first
3 and second reset breakpoints is satisfied.

1 40. The program debugger of claim 34, wherein said first Boolean expression
2 is partially invariant within the loop, and said program debugger further comprises:
3 means for extracting, from program code within the loop, a second Boolean
4 expression that is invariant within the loop,

5 wherein said special conditional breakpoint conjunctively includes said second
6 Boolean expression, and said first Boolean expression is invariant within the loop
7 when said second Boolean expression is satisfied.

1 41. The program debugger of claim 40, further comprising:
2 means for setting, at a first loop exit program position, a first reset breakpoint;
3 and
4 means for reestablishing said initial conditional breakpoint if said first reset
5 breakpoint is satisfied.

1 42. The program debugger of claim 41, further comprising:
2 means for removing said first reset breakpoint if said first reset breakpoint is
3 satisfied.

1 43. The program debugger of claim 41, further comprising:
2 means for setting, at a second loop exit program position, a second reset
3 breakpoint; and
4 means for reestablishing said initial conditional breakpoint if one of said first
5 and second reset breakpoints is satisfied.

1 44. The program debugger of claim 43, further comprising:
2 means for removing said first and second reset breakpoints if one of said first
3 and second reset breakpoints is satisfied.

1 45. A method of reducing debugger impact through conditional breakpoint
2 motion, comprising:
3 extracting, from an initial conditional breakpoint within a program loop, a first
4 Boolean expression that is at least partially invariant within the loop;
5 setting, at a pre-ICB program position, a special conditional breakpoint that
6 includes the complement of said first Boolean expression; and
7 if said special conditional breakpoint is satisfied, removing said initial
8 conditional breakpoint.

1 46. The method of claim 45, wherein said first Boolean expression is
2 completely invariant within the loop.

1 47. The method of claim 45, further comprising:
2 setting, at a first loop exit program position, a first reset breakpoint; and
3 if said first reset breakpoint is satisfied, reestablishing said initial conditional
4 breakpoint.

1 48. The method of claim 47, further comprising:
2 if said first reset breakpoint is satisfied, removing said first reset breakpoint.

1 49. The method of claim 47, further comprising:
2 setting, at a second loop exit program position, a second reset breakpoint; and
3 if one of said first and second reset breakpoints is satisfied, reestablishing said
4 initial conditional breakpoint.

1 50. The method of claim 49, further comprising:
2 if one of said first and second reset breakpoints is satisfied, removing said first
3 and second reset breakpoints.

1 51. The method of claim 45, further comprising:
2 extracting, from the program code within the loop, a second Boolean
3 expression that is invariant within the loop,
4 wherein said special conditional breakpoint conjunctively includes said second
5 Boolean expression, and said first Boolean expression is invariant within the loop
6 when said second Boolean expression is satisfied.

1 52. The method of claim 51, further comprising:
2 setting, at a first loop exit program position, a first reset breakpoint; and
3 if said first reset breakpoint is satisfied, reestablishing said initial conditional
4 breakpoint.

1 53. The method of claim 52, further comprising:
2 if said first reset breakpoint is satisfied, removing said first reset breakpoint.

1 54. The method of claim 52, further comprising:
2 setting, at a second loop exit program position, a second reset breakpoint; and
3 if one of said first and second reset breakpoints is satisfied, reestablishing said
4 initial conditional breakpoint.

1 55. The method of claim 54, further comprising:
2 if one of said first and second reset breakpoints is satisfied, removing said first
3 and second reset breakpoints.

1 56. An article of manufacture comprising a computer program medium
2 readable by a computer and embodying one or more instructions executable by the
3 computer to perform a method of reducing debugger impact through conditional
4 breakpoint motion, the method comprising:

5 extracting, from an initial conditional breakpoint within a program loop, a first
6 Boolean expression that is at least partially invariant within the loop;

7 setting, at a pre-ICB program position, a special conditional breakpoint that
8 includes the complement of said first Boolean expression; and

9 if said special conditional breakpoint is satisfied, removing said initial
10 conditional breakpoint.

1 57. The article of manufacture of claim 56, wherein said first Boolean
2 expression is completely invariant within the loop.

1 58. The article of manufacture of claim 56, wherein the method further
2 comprises:

3 setting, at a first loop exit program position, a first reset breakpoint; and
4 if said first reset breakpoint is satisfied, reestablishing said initial conditional
5 breakpoint.

1 59. The article of manufacture of claim 58, wherein the method further
2 comprises:

3 if said first reset breakpoint is satisfied, removing said first reset breakpoint.

1 60. The article of manufacture of claim 58, wherein the method further
2 comprises:

3 setting, at a second loop exit program position, a second reset breakpoint; and
4 if one of said first and second reset breakpoints is satisfied, reestablishing said
5 initial conditional breakpoint.

1 61. The article of manufacture of claim 60, wherein the method further
2 comprises:

3 if one of said first and second reset breakpoints is satisfied, removing said first
4 and second reset breakpoints.

1 62. The article of manufacture of claim 56, wherein the method further
2 comprises:

3 extracting, from the program code within the loop, a second Boolean
4 expression that is invariant within the loop,
5 wherein said special conditional breakpoint conjunctively includes said second
6 Boolean expression, and said first Boolean expression is invariant within the loop
7 when said second Boolean expression is satisfied.

1 63. The article of manufacture of claim 62, wherein the method further
2 comprises:

3 setting, at a first loop exit program position, a first reset breakpoint; and
4 if said first reset breakpoint is satisfied, reestablishing said initial conditional
5 breakpoint.

1 64. The article of manufacture of claim 63, wherein the method further
2 comprises:

3 if said first reset breakpoint is satisfied, removing said first reset breakpoint.

1 65. The article of manufacture of claim 63, wherein the method further
2 comprises:

3 setting, at a second loop exit program position, a second reset breakpoint; and
4 if one of said first and second reset breakpoints is satisfied, reestablishing said
5 initial conditional breakpoint.

1 66. The article of manufacture of claim 65, wherein the method further

2 comprises:

3 if one of said first and second reset breakpoints is satisfied, removing said first

4 and second reset breakpoints.

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